Factors affecting student drop out from the university introductory physics course, including the anomaly of the Ontario double cohort

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Abstract: The course drop-out rate is the fraction of students per year who drop a course after starting it. This statistic is important both as a measure of the difficulty or relevance of the course compared to others at a university, and as one indication of the success of measures taken to improve teaching. The drop-out rate of students from the first-year university physics course at Trent University increased from about 8% in the 1980s to over 20% in 1999, primarily under the same instructor, with the exception of the Ontario "double-cohort" years 2003–2004 and 2004–2005 when it plummeted to about 9% before rebounding in 2005–2006. A similar decrease in this rate for the double-cohort years has been observed at Brock University and the University of Guelph, and so was probably widespread. It is speculated that the main cause of the decrease for these two years was an improved work ethic of the double-cohort students. Possible causes of the steady increase in the drop-out rate from the 1980s to the present are discussed including high-school courses taken; gender balance; and grade inflation. The last of these combined with a dramatic increase in the percentage of high-school students continuing their education, appears to have resulted in weaker and less motivated students being admitted to university. Results are also given of a survey of recent first-year Trent University physics students for possible reasons for dropping out of the course: students who have not taken the final-year high-school physics course, do not live in residence, or do not work together on their assignments are much more likely to drop the course.

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Résumé : Le taux d'abandon dans un cours est la fraction des étudiants qui abandonnent un cours après s'y être inscrit. Cette statistique est importante à la fois comme mesure de la difficulté ou de la pertinence du cours comparativement à d'autres cours offerts à l'université et comme un indicateur du succès des mesures mises de l'avant pour améliorer l'enseignement. Le taux d'abandon d'étudiants en physique de première année à l'université Trent est passé de 8 % dans les années 1980 à plus de 20 % en 1999, essentiellement avec le même professeur, avec l'exception des années de la double cohorte de l'Ontario en 2003–2004 et 2004–2005, où il a plongé à 9 %, avant de rebondir en 2005–2006. Une diminution comparable de ce taux a été observée lors de la double cohorte à l'université Brock et à l'université de Guelph et était probablement généralisée. Il a été suggéré que la cause première de cette diminution au cours de ces deux années était une meilleure éthique de travail dans la double cohorte. Nous étudions les causes possibles de l'augmentation du taux d'abandon entre les années 1980 et aujourd'hui, y compris les cours suivis à l'école secondaire, la balance des sexes et l'inflation des cotes. Le dernier de ces facteurs, en combinaison avec une augmentation importante du pourcentage de diplomés du secondaire qui poursuivent leurs études, semble avoir permis à des étudiants plus faibles et moins motivés d'être admis à l'université. Nous présentons aussi les résultats d'un sondage sur les raisons possibles d'abandon du cours des étudiants récents de première année en physique à l'université Trent. Les étudiants qui n'ont pas suivi le cours de dernière année au secondaire, qui ne vivent pas en résidence ou qui ne travaillent pas en groupe sur les devoirs ont une plus grande probabilité d'abandonner le cours.

[Traduit par la Rédaction]

1. Introduction

The course drop-out rate is the fraction of students per year who drop a course after starting it. This statistic is important for several reasons: as a historical indicator of student preparedness (both academic, and in level of maturity and work habits); as a measure of the difficulty or relevance of the course compared to others at the university; and as one indication of the success of measures taken to improve teaching. Any information that can be used to decrease the drop-out rate is beneficial for the students involved; for the university, which can use its resources more effectively; and for society, which benefits from earlier graduation into the workplace.

There is considerable literature on factors affecting the retention of post-secondary students in general. The main conclusion (for example, see ref. 1) is that students who are well integrated both socially and intellectually into college or university life are more likely to remain in university than those who are not well integrated. Reference 1, p. 82, even concludes

> For most departures, leaving has little to do with the inability to meet formal academic requirements.

There is also a substantial literature on retaining students in the sciences (for example, see ref. 2), but relatively little is directed towards what affects retention within a specific university physics course. For example, a search under "retention"

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Table 1. Drop-out rate (%) of students in the introductory course, as a function of the entry year. Double-cohort is shown in bold.

Year	Trent drop rate (%)	No. of students at test #1	Final course av.	% with Gr 13/OAC/4U physics	% with Gr 13/OAC/4U calculus	% female	Male drop rate (%)	Female drop rate (%)	Brock drop rate (%)
1981	7	29	63.8			28	10	0	
1982	8	36	66.5			44⁺	5	6	
1987	8	38	65.1			29	7	9	
1988	2	51	67.2	71	91	35	0	5	
1989	2	57	74.4	85	100	36	0	5	
1992*	12	53	51.1			29	14	7	
1993	11	50	70.6			37	11	10	
1994	9	69	71.3	77	89	42	11	7	
1995*	7	59	67.5	81	91	40	3	13	
1996	16	62	67.4	82	95	39	13	21	
1998	16	45	61.9			33	13	20	
1999	28	58	66.9	89	93	42	21	38	26
2000	25	76	66.5	89	93	36	20	32	13
2001*	21	68	62.4	79	89	37	28	8	19
2002**	21	62	61.6						21
2003	**8**	**87**	**63.2**			**39**	**8**	**9**	**8**
2004**	**10**	**67**	**64.4**						**7**
2005	27	77	69.8	66	82	38	23	35	10
2006⁺⁺	29	85	65.6	72	94	38	23	34	

*One term taught at Trent by instructor B.
**Both terms taught at Trent by instructor C.
+A large number of students were female Malaysians.
++One term taught at Trent by instructor D.

in the *American Journal of Physics* turned up only two articles that referred to the retention of students, while a search under "drop-out" gave no results. In the *Physics Teacher*, the other main North American publication on physics teaching, searches under these two words turned up no articles on retaining students in courses. Of the two articles in the *American Journal of Physics*, one [3] is primarily a discussion of the enhanced academic success of students in a class with a high degree of student–student interaction. Its main conclusion was that the socialization promoted by the cooperative learning environment was the most important factor in the academic gains. The article's abstract claims substantial increases in retention in under-represented groups, but does not quantify the retention aspect further. The second article [2] is a review of 20 studies on the recruitment and retention in science of women and minorities. The recurring theme that is relevant to all students is that retention improves for students placed in cooperative learning environments.

The current paper looks specifically at the factors affecting the drop-out rate within a single introductory-physics course, at Trent University in Ontario, Canada. The paper has two major components. The first is a review of the drop-out rate from the 1980s to the present, which shows a steady and large increase in the rate over this time with a rapid increase starting around 1996, with the exception of the two year anomaly of the "double-cohort" when the drop-out rate plummeted back to 1980 levels. This anomaly is also seen in other Ontario universities. Possible reasons for both the overall increase and the abrupt change in the double-cohort years are discussed. The second component gives the results of a recent student survey that explores potential reasons for dropping the course at the present time.

2. Changes in the drop-out rate since the 1980s and the anomaly of the double-cohort years

For graduation years 1989–2002, high schools in the province of Ontario included grades 9 to 12, plus an OAC (Ontario Academic Credit) system designed for university-bound students. Although students could, in principle, graduate in four years with enough OAC courses to enter university, the vast majority spent a full five years in high school. To bring Ontario into line with all other Canadian provinces, Ontario decided to reduce this time to four years by revising the curriculum to put the OAC material into grades 9 to 12, thus eliminating the OAC year totally beginning in September 2003. (The fourth-year courses for university-bound students under the revised curriculum are called 4U courses.) Therefore, the final year of high school in 2002–2003 included both those students completing their OAC courses, and those who had started high school a year later and were taking 4U courses.

This "double-cohort" would graduate at the same time, which was expected to nearly double the number of students seeking to enter university in September 2003. However, 22% of the first 4U students stayed at high school for a fifth year [4] for various reasons: to avoid the competition for university places, improve their grades, or take elective courses that they missed because of the more compressed 4U schedule. Because of the large number

of students who stayed for this extra year, the major part of the double-cohort phenomenon at universities really extended over two years: 2003–2004 and 2004–2005. It was widely believed that there would not be enough places at university for all of these students, so that the pressure to do well in high school to guarantee a place at university was extremely high for these students. In the end, the Ontario government put enough extra funding into the system to guarantee a university place for every qualified student, but it was not obvious that this would be possible even towards the end of 2002–2003, and there was considerable anxiety within this group of students.

The second column of Table 1 shows the drop-out rate from the two-term introductory physics course at Trent University from the academic year 1981–1982 to the present. The year stated is the entry year. To avoid counting the significant number of students who adjust their courses at the beginning of the school year, the drop-out rate (for Trent) has been taken as the percentage of those students who were present for the first test in late October but who dropped the course before the end of the academic year (i.e., did not write the final exam, excepting those who had legitimate reason such as illness). The years shown in Table 1 are those in which the course was taught by the author, with the exception of 1992–1993, 1995–1996, and 2001–2002 when one term of the course was taught by Instructor B; 2002–2003 and 2004–2005 when the entire course was taught by Professor C; and 2006–2007 when the second term was taught by Professor D. There was no appreciable effect in the drop rate caused by the change in instructors in the other five times the course was taught in part or in full by a different instructor, which suggests that this was also true for the double-cohort year 2004–2005. Over the full period shown in Table 1, the material taught was largely the same, at a consistent level of difficulty and with the same required high-school courses (final year calculus or algebra), and there have been only minor fluctuations (1.2% standard deviation) in the minimum entrance average required by Trent University from high school over the period from 1993 to the present, for which the data were easily available. The style of teaching did change significantly from a primarily lecture-based mode to a student-interaction mode (Peer Instruction [5]) beginning in 1998–1999, but without any dramatic effect on the drop-out rate that year, so it seems unlikely that this change in style had a major effect on the drop-out rate in later years. The dramatic decrease in the drop-out rate during the double-cohort years, back to 1980s levels as seen in Table 1, further supports the claim that the rapid rise after 1999 was not caused by the change in teaching approach.

Table 1 shows a steady increase in the drop-out rate from this course with time, by a factor of three from about 8% in the 1980s to well over 20% in the last few years. (A change in drop-out of only two persons in a class of 50 will change the rate by 4%, so fluctuations of this order from year to year are not significant.) The main exception to this increasing trend is the dramatic decrease in the drop-out rate for the two double-cohort years, when it fell to levels close to those of the 1980s. It is difficult to get reliable data from other universities because of changes in instructor, multiple class sections, or the practice of bell-curving grades, which may influence drop-out rates, but data deemed reliable were obtained from Brock and Guelph Universities. The data from Brock[1] in Table 1 from the period 1999–2005 are similar to those from Trent, although the rebound in Brock's drop rate for 2005–2006 was not as dramatic. At Brock, there were two instructors teaching introductory courses from 1999 to 2005, one of whom was the same during this time. Data from the University of Guelph[2] do not include pre-double cohort figures, but support this general pattern from 2003 onwards: the drop rate, averaged over three different first-year physics courses with mostly the same instructors, increased from an average of 5.7% in the fall term of 2003 (a double-cohort year) to 7.3% and 9.5% in the fall terms of 2004 and 2005, and from 6% in the winter term of 2004 to 6.9% and 11% in the winter terms of 2005 and 2006. There is no obvious reason why the drop-out rate should rebound more quickly at Trent after the double cohort than at Brock or Guelph. These data raise three important questions: why has the drop-out rate increased so dramatically at Trent between 1981 and the present; what can be done about the increased drop rate; and why did this rate decrease so much during the double-cohort years, and then rebound? The final question will be discussed first.

In the absence of student exit surveys that spanned the period from before 2003–2005 to after, the best one can do is speculate as to the reason for the dramatic decrease in the drop rate during the double-cohort years. The most likely reason is that the double-cohort students were highly motivated by the competition to garner a university position at a time when it seemed certain that there would not be enough to go around. Therefore, they developed a work ethic and work habits that remained with them into university: they stayed up-to-date in their university studies and so were less likely to drop out. This suggestion is supported by anecdotal evidence from high-school teachers that these students were much more concerned about performance than students immediately prior to 2003–2004. It is also supported by the anomalously high average grade for high school students applying to universities in 2003 (Fig. 1) [6]. While one could argue that the increased retention in 2003–2004 was because the best students entered university that year, this cannot apply to the second year of the double cohort, which also had a low drop-out rate. This raises the question whether the increase in the drop-out rate since 1988 was due to gradual erosion in the student motivation, work ethic, and work habits over the years. If this is the case, as is supported by data discussed in the following section, then the evidence from the double-cohort class shows that this trend can be reversed, and reversed within a very short time, by changing the attitudes of high-school students. The question of how to do this is beyond the scope of this report.

3. Possible causes of the increase in the drop-out rate

3.1. Grade inflation

One possible cause of the increase in the drop-out rate with time is grade inflation. If the average high-school grade has been increasing over the years, one must ask if we are seeing weaker students even though the effective entrance standard has not changed much. Specific examples of grade inflation in high schools are well documented; for example, see the Appendix

[1] S. Bose. Brock University, Ont., Canada. Private communication. 2006.

[2] J. O'Meara and E. McFarland. Guelph University, Ont., Canada. Private communication. 2006.

Fig. 1. Average grade of Ontario high-school graduates applying to Ontario universities.

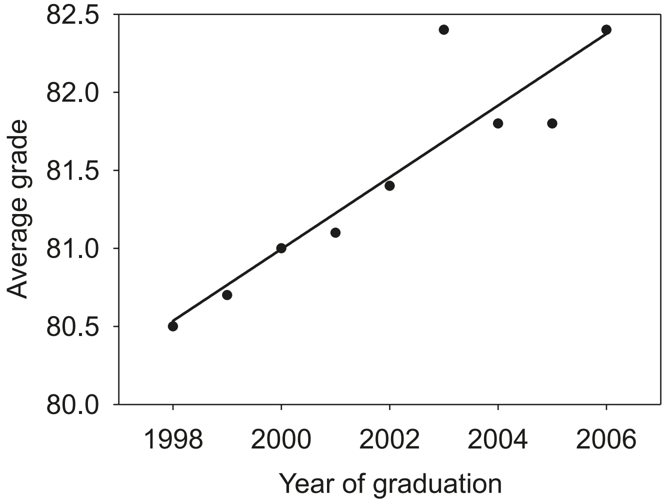
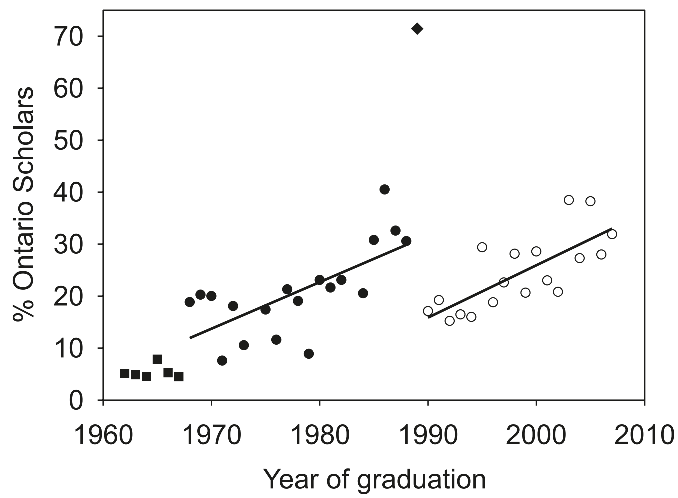


Fig. 2. Percentage of Ontario Scholars in high-school graduating class.



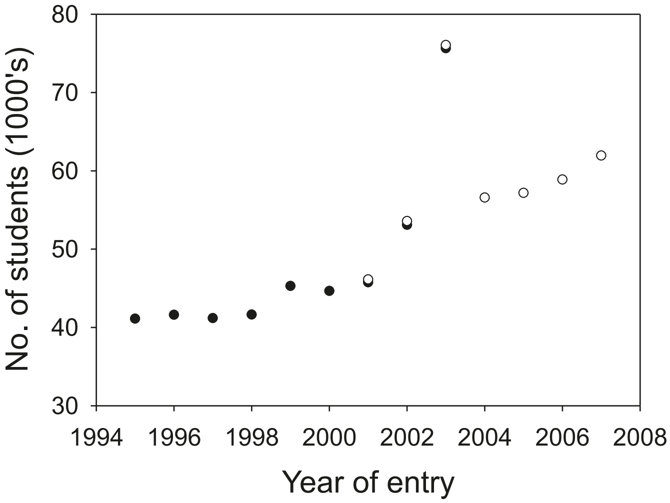
of ref. 7. However, no published time-sequence data could be found. The Ontario Ministry of Education has only just started to collect centralized data on its students, although limited information on this issue, reported below, is available from the Ontario Universities' Application Centre (OUAC) from 1998 onwards.

Therefore, it is necessary to go to individual schools to obtain any data before 1998. Ontario has designated graduating students with a final-year average of at least 80% as Ontario Scholars since about 1962. Figure 2 shows the percentage of eligible students at one local high school who received these awards, taken from the graduation ceremony booklet for each year [8]. There is no reason to think that the trend in the data of Fig. 2 is not roughly representative of the entire province. From 1962 to 1988 the eligible students were only those earning "Honours Graduation Diplomas" from grade 13. The final exams were set and graded by the province until 1967–1968 when individual schools took over this responsibility, opening the door for grade inflation. (At this local high school, the number of Ontario Scholars increased to 19% in 1968 from its previous maximum of 8%.) The school system was revised in 1989 with the official elimination of grade 13 and the introduction of the Ontario Academic Credits; students with at least six OAC credits and an average of about 65% were eligible for university entrance. It was then possible for a student to complete high school in four years, but most continued to take five. (Table 1 indicates that the physics drop-out rate began to increase significantly after 1989 which, speculatively, might be related to the loss of a distinct capping year of study for university-bound students.) From 1990 onwards, all secondary school graduates, both university- and college-bound, were eligible for Ontario Scholarships. This increased the applicant pool by almost three times but the student average in the expanded group was apparently lower than previously. As can be seen in Fig. 1, this caused the percentage of students gaining Ontario Scholarships to fall from 31% in 1988 to 17% in 1990. The move to a four year school system in 2003 shows no significant effect in Fig. 2. Therefore, the data before and after 1989 have been fitted separately with straight lines, with the anomalous point from 1989, due to the introduction of the OAC system, omitted from the fits. The regression analyses before and after 1989 give annual increases of 0.9 ± 0.2 and 1.0 ± 0.2% per year, respectively, in the fraction of graduating students with an average of 80% or higher. Therefore, there is clear evidence of grade inflation; the sixfold increase between 1962 and 1988, and the similar rate of increase since 1988, are too large to be attributed to students being more capable. In fact, evidence discussed below shows a decrease in performance in students entering university, at least in some areas.

Other data that support the argument for grade inflation are given in Fig. 1. All applicants to Ontario universities from Ontario high schools have had to apply since 1996 through the OUAC, which makes data available to the universities. Figure 1 shows the average high-school grade of students applying, from 1998 to the present. The high point for 2003 is for the first year of the double cohort. The linear regression analysis gives an increase in this average grade of 0.23% per year. If this rate were constant over the period 1967–2007 of Fig. 1, this would represent an overall grade inflation of 9% in this time period.

However, this does not, in itself, imply that students entering university today are on average 9% weaker than in 1967. Over this time, the minimum average required for Ontario university entrance has increased from 60% in the mid 1960s to an official 65% today while the de facto minimum entrance requirement is now about 70%. Therefore, it might be argued that this increase in entrance standards has compensated for grade inflation. However, there is strong evidence [7] that the average high-school student entering university today is, indeed, weaker than in the past. For example, the average grade on the same chemistry test administered to incoming chemistry students at one Ontario university fell from 64% in 1978 to 48% in 1996 [9], and the performance of Trent's introductory physics class on an identical first test was 66% in 1996 and 50% in 2006. Moreover, four of the five lowest grades on the first test in this course have occurred in the last four years, with the lowest in 2006. The recent drop in performance was not restricted to my course; our mathematics department reported similar drops in performance, as has Brock University for their mathematics and physics students[1].It is argued elsewhere [10] that much of the decline in performance since the double cohort is related to an increased reliance on rote memorization over analytical ability that seems to have accompanied the new,

Fig. 3. First-year university enrolment as a function of year of entry.



more content-intensive, primary and secondary curriculum introduced in Ontario in 1997 and 1998. However, the students already in high school at the time of implementation of this new curriculum remained with the previous curriculum until they graduated in 2003, so this cannot explain the rapid rise in the drop-out rate of Table 1 that saw a doubling of the drop-out rate in Table 1 between 1995 and 1999.

To explain this rapid rise, we turn to the analysis of Côté and Allahar [7] who argue that a large percentage of students are now going to university, not because they have any desire to learn, but only for the credential required for a job. These "disengaged" students do not have the motivation, and often not the work habits, to succeed at university. Côté and Allahar blame the increased numbers of such students on the decline in the number of good jobs accessible with only a high school diploma, which began in the late 1970s. Governments, as a result, have publicized widely that a university degree is needed for the rewarding jobs of the future. This has become a self-fulfilling prophecy as more employers, just because university graduates are available, now require this credential for jobs that previously were handled by someone with a high school education. Côté and Allahar state that this has been the main cause of the increase in postsecondary participation rate (fraction of high-school students continuing to postsecondary education), and has added to the pressure on grade inflation as high schools are being pushed to increase the percentage of graduating students.

The first-year enrolment at Ontario Universities since 1995 is given in Fig. 3. Figure 3 is a compilation of data from two sources:

(1) Ontario Undergraduate Student Alliance, Issue Briefings on Enrolment (http://www.ousa.ca/sef/page/id/34.html) for universities in Ontario; data originally from the Ministry of Training, Colleges and Universities, and

(2) the number of admitted (confirmed) students from Ontario high schools, from the Ontario Universities Application Centre (http://www.ouac.on.ca/news/news.html).

The overlap in the data for 2001–2003 shows that the two sources represent essentially the same data. Enrollment was fairly flat near 41 000 from 1995 to 1998, jumped about 10% in 1999, and has risen rapidly since 2002 to around 62 000 in 2007. The rapid rise starting in 1999 can be explained using data from a recent study [11] that shows a doubling in the full-time university participation rate from 9% in 1997–1998 to 19% in 2005–2006, at the same time as the Ontario population age 17–29 increased about 12% from 2 million in 1997 to over 2.2 million in 2007 due to the "baby-boom echo". If we accept that most of the increase in participation rate is being driven by credentialism — the desire for a credential rather than the desire to learn — then much of the recent rapid rise in the drop-out rate from our introductory physics course is likely due to this cause. That is, many students are lacking the academic preparation, motivation, or study habits to keep up with the rapid pace of a university course.

The situation recently has been further complicated by the Ontario Ministry of Education's attempts to increase the fraction of students completing high school. These include a policy beginning in 2000 that greatly reduces the ability of teachers to deduct marks for lateness of assignments as long as they are eventually submitted, and a "credit recovery" program started in 2005 that allows students with a grade in the 40's to obtain a pass by repeating just the failed components of the course. Although there were good reasons for these changes, and the high-school completion rate has increased since then, there is concern that this is allowing more marginal students to attend university and may have contributed to the high drop-out rate in the last few years. Regardless, it seems likely that grade inflation reflected in poorer average preparation of incoming students can be blamed for at least part of the increasing drop-out rate over the years.

Of course, grade inflation also causes serious effects elsewhere. For example, the compression of grades at the top end makes it difficult to discriminate among the best high school students when awarding scholarships. One possible way of eliminating grade inflation without returning to province-wide exams is to require that all high schools bell-curve their grades to a specified mean and standard deviation, on the assumption that any hundred or so graduating students would have very similar native abilities, and the best of these will have the motivation and work habits to succeed at university even if their high school has prepared them slightly less well than students from another school.

Finally, significant grade inflation is also happening at Canadian universities with, for example, the percentage of A's and B's in first-year courses in seven universities sampled [12] increasing from 48.2% to 53.3% from 1973–1974 to 1993–1994. Evidence shows a continuation of grade inflation to the present [7, pp. 196–197]. These data are supported by a recent Statistics Canada survey [13], that reports that 69% of age 24–26 Canadian postsecondary students in 2005, who had not yet graduated, had obtained first-year averages in the A and B range. For comparison, the average end-of-year grade in Trent's introductory physics course is also recorded in Table 1. It is seen that there has been no grade inflation in this course over this time.

We now turn to other possible causes of the increase in drop-out rate.

3.2. Background preparation in mathematics and physics

A second possible cause of the increasing drop-out rate could be changing mathematics or physics preparation of students over the years. We have regularly surveyed the class at the

start of each year, including a question on what advanced high-school mathematics and physics courses they have taken. We no longer have all of these records, but the results available are given in Table 1. (Attempts were also made to obtain this information from data supplied by the Ontario Universities Application Centre (OUAC) for the period 1995–2006. However, this gave information on typically only half the students in the course, as the OUAC data references only Ontario high-school credits, and it appears that not all these records are complete.) Note that the Trent surveys were done at the start of the year and some students will have dropped the course before the first test, so that the group replying to this survey and that writing the first test are slightly different. Nevertheless, the data are informative. The fraction of students with high-school calculus has remained fairly steady at just over 90%. The percentage taking the final-year algebra course was also roughly constant at about 77%. The percentage of students with the final-year high-school physics course has been fairly constant at about 80% (with the unexplained exception of the 71% in 1988–1989), except for the last two years when this dropped to 66% and 72%. It is unfortunate that we are missing these data for the double-cohort years, but it is clear that the general increase in drop-out rate since the 1980s is not caused by a decrease in the number of students taking high-school physics or mathematics. Nevertheless, given the results presented in Sect. 4 of this paper, it seems likely that the very high drop-out rates in the last two years is partially a reflection of the lack of physics preparation.

3.3. Gender effects

Another possibility is that the increase in the drop-out rate could be related to the increasing participation of female students at the university level. The percentage of female students in our introductory physics course, and their drop-out rate relative to the males, are given in Table 1. There has not been a significant increase in the percentage of female students taking this course over the years, although there has been a significant increase in the percentage of females continuing to a major in physics. Moreover, there is no obvious difference in the percentage of males and females that have dropped the course, although these percentages fluctuate greatly from year to year, so gender does not appear to be a significant factor.

Other systemic effects are of potentially greater importance to the drop-out rate including, for example, the general move from full-year high-school courses to semestering that began in the early 1970s, which increased the class time from about 50 to 75 min but reduced the amount of material covered; 75 min was too long for continuous teaching so some class time was allotted to homework. Nevertheless, the most important result of the data of Table 1 is that, in spite of all the system changes since 1981, the drop-out rate in the double-cohort years 2003–2005 actually fell back to the level of the 1980s. The main conclusion seems to be that changes in the motivation, work ethic, and work habits of high school students is the main culprit here, and this can be reversed if the external motivation is high enough.

4. Possible influences on the drop-out rate for current students

Even if the abilities and attitudes of student graduating from high school cannot be changed, it may be possible to reduce the drop-out rate in other ways, such as by requiring different high school courses or by changing student habits once they do arrive at university. We carried out a survey at Trent in March of 2005–2006, to try to determine which of a variety of potential causes might contribute to the current drop-out rate, including

(1) hours per week working (to pay for their education),

(2) long commuting times,

(3) a culture of dropping out in high school and in university,

(4) years off after high school,

(5) high-school physics background,

(6) high-school math background,

(7) whether or not a student lived in residence, and

(8) whether or not students worked on assignments with their peers.

The Trent introductory-physics course uses calculus liberally to derive formulae as needed, but does not require the students to use calculus on assignments or tests. Therefore, either high-school calculus or algebra is a prerequisite for the course, although university calculus is a prerequisite for subsequent physics courses. As with most introductory physics courses at the university level, it covers all the high-school physics material again but at a much faster rate. Therefore, although it is recommended, high-school physics is not a prerequisite for this course, to allow students to obtain the university physics they may require for their programs even if they did not take it in high school. Such students are told that they will have to work harder in the first term to make up this lack of preparation.

As of 1 October 2005, there were 92 students in the course, of whom about 70 were in first year. Only the first-year students are included in the results reported here. There were 22 replies to the survey from year-1 students who were still enroled (called the "Stays"), and 17 replies from year-1 students who had dropped the course (called the "Drops"), for a 53% response rate. All of the Drops had continued to take some university courses. The questionnaire is given in Table 2, and the average results are given in Table 3 for most of the variables. Commuting time was not a significant factor: only six of the Stays and three of the Drops commuted further than 15 km, and the average time for these individuals was 33 min for both groups. Six of the 17 students who dropped the course said that they planned to take it in the future. However, only one of them registered for 2006–2007 and soon dropped it again.

We use the statistic p to decide if a specific variable affects the drop-out rate, where p is the probability that a given variable does not have a significant effect. In studies such as this, $p < 0.05$ is normally taken to imply statistical significance, whereas $p > 0.05$ normally implies a lack of statistical significance. For example, for the question "Do you live in residence at Trent?" the value of $p = 0.002$ means that there is a 99.8% chance that the average responses of the two groups are significantly different. That is, living in residence is strongly associated with remaining in the course.

Variables fall into two basic classes: (1) *categorical* (when there is no intrinsic ordering involved which, in our case, applies when the questions can be answered with a simple yes/no), and (2) *continuous* with a mean and standard deviation. The

Table 2. Survey of possible factors affecting the drop-out rate in Physics 100, 2005–2006.

1.	How many university courses will you have completed by the end of this academic year? (Count a half course as 0.5 courses.) _____
2.	Do you live in residence at Trent ______ or off-residence ____?
3.	Do you commute more than 15 km to Trent? ______ If so, about how long does it take you to travel from home to Trent? _____
4.	How many years were you in high school? ____
5.	If relevant, how many years were you out of high school before starting university? _____
6.	Do you have a high-school physics credit at the final-year level? ____
7.	What high-school mathematics credits do you have at the final-year level? ________________
8.	Did you drop any courses in high school? If so, how many? ______
9.	If you dropped any high-school courses, did you have a paying job at the time you dropped them? ______ If yes, for about how many hours per week? _________
10.	Have you dropped any other courses at Trent? _____. If yes, how many? ____ (Count a half course as one.)
11.	Do you/did you work regularly with other students on Physics 100 assignments? _____
12.	If you dropped Physics 100, about when did you stop coming to classes? _______
13.	If you dropped Physics 100, did you have a paying job at the time you dropped it? ____ If yes, about how many hours per week were you working at the time? _______
14.	If you are still in Physics 100, do you have a paying job? ____ If yes, about how many hours per week are you working? _______
15.	About how many people do you know who have dropped university courses this year? _____
16.	If you have dropped Physics 100, do you plan on taking it in the future? _____
17.	Please provide any other information that might be useful. ________________________

statistical dependence of one categorical variable on another is tested by evaluating the Pearson χ^2 statistic: in our case, a value greater than the "critical value" of 3.84 indicates dependence at the $p < 0.05$ level. The statistical dependence of a categorical variable (continued enrolment in Physics 100) on a continuous variable can be calculated using a t-test as long as the homogeneity of variance is not violated; i.e., as long as the Brown–Forsythe p is greater than 0.05. This is true for all our continuous data except for the number of other university courses dropped. For this variable, a Mann–Whitney U test was used instead. All the statistical analysis used WebStatistica [14]. The results are given in Table 3.

The first two rows of values in Table 3 represent either the percentage of students who responded "yes" to a yes/no question (columns 2 to 7), or the average of the replies in the case of a question requiring a numerical answer, such as the number of other courses dropped (columns 8 to 13). The next two rows are the standard deviations of the responses where appropriate; in some cases, such as the number of hours worked per week at high school, the standard deviation is larger than the average because only a few students worked, but those students worked long hours. The next row gives the Pearson χ^2 parameter, when relevant. The last row is the p value.

At the $p < 0.05$ level, there is no significant dependence observed for the number of years off between high school and university, or from outside work either in high school or at university (three students who worked 25–30 h per week while at university did drop the course, but three students who worked between 17–27 h per week did not drop it).

There also is no statistical indication that the Drops had a higher culture of dropping high-school courses than the Stays, although the Drops had a much higher average number of other university courses dropped, 0.88 compared to 0.18 for the Stays for $p = 0.02$. Of course, this could just mean that the Drops were weaker students and, therefore, had difficulty with more than their physics courses. Both groups knew comparable numbers of other students who were dropping courses.

However, there is a very strong dependence between the number of Drops and the lack of high-school physics: 82% of Drops did not have high-school physics, compared to only 29% of the Stays, for $p = 0.003$. This parallels results at the University of Guelph,[2] and at the University of Calgary.[3] In the latter case the drop rate was four times as high in an introductory course specifically designed for students without the final-year high-school physics course than in the sister course for students with high-school physics. This finding is counter to the general conclusion by Tinto, who claimed that [1, p. 82],

> Voluntary departure appears to be the result more of what goes on after entry into the institution than of what may have occurred beforehand.

There is some evidence, discussed elsewhere [10] that current students often depend primarily on memorization in high school and are relatively weak in the analytical skills needed in physics. The fast pace of a university course may not allow the time to develop those skills if they have not already started to develop them in a high-school physics course. Alternatively, the much larger drop rate for students who have not previously taken physics may be due to preselection: students who had already found physics difficult at the high-school level may not even try it at university.

There is some indication, at $p = 0.19$, that the probability of staying in the course is improved by taking high-school calculus but, rather surprisingly, there is a much weaker dependence on

[3] R. Thompson. University of Calgary, Alta., Canada. 2006.

Table 3. Average responses to the questionnaire of Table 2.

	In res	Work together	HS Physics	HS Mathematics Calculus	Alg.+Geom.	Finite/DM	Yrs off before U	HS courses dropped	HS job hr/wk	Other U courses dropped	U job hr/wk	No. friends dropping
Stays	64%	82%	82%	86%	41%	32%	0.954	0.41	2.8	0.18	3.1	6.0
Drops	18%	44%	29%	53%	29%	35%	1.08	0.53	6.7	0.88	4.7	4.4
sd Stays							2.28	0.85	7.4	0.40	9.2	5.50
sd Drops							1.97	0.91	12.1	1.20	11.5	4.50
Pearson χ^2	5.55	8.09	8.77	1.73	0.05	0.13						
p	0.002	0.004	0.003	0.19	0.83	0.72	0.91	0.30	0.13	0.02	0.39	0.51

res = residence; U = university; HS = high school; DM = data management; sd = standard deviation; p = probability the difference is not significant.

taking Algebra and Geometry, or the Finite Math (OAC) or Data Management (4U) courses, which included some statistics.

As mentioned earlier, students living in residence had a much higher chance of staying in the course: 64% of the Stays lived in residence, compared to only 18% of the Drops, for $p = 0.002$. Similarly, students who work with others on assignments (82% of the Stays versus 44% of the Drops, for $p = 0.004$) have a much higher probability of staying in the course than those who do not. The results for these last two groups are consistent with other studies (see, for example, ref. 1) that show that students who are well integrated into university life socially and intellectually are more likely to complete their degrees. They feel fulfilled by their studies, they know that their problems are not unique to them, and they have a support group of their academic peers that helps develop their self-confidence. In addition, those who work in physics study groups are more likely to obtain a better understanding of the material.

5. Conclusions

The main conclusions that can be drawn from the above data are the following:

1. The Ontario double-cohort results suggest that a major contributor to the increasing drop-out rate from the introductory physics course is deteriorating work ethic and work habits of the students. If so, it seems possible to change these dramatically over the four years of high school, given adequate external motivation.

2. Students, physics teachers and high-school guidance counsellors should be informed of the great importance of taking high-school physics if there is any chance of the student requiring a university course in the subject, even if there is no formal prerequisite for high-school physics.

3. Students entering university, especially those who are living off-residence, should be made aware of the importance to their academic success of integrating fully into university life, including the development of a peer support group. In Physics, this may be most effectively accomplished by working on assignments and studying with other physics students.

4. The coupling of credentialism — as a major motivator for a university degree — with significant high-school grade inflation has resulted in a greatly increased postsecondary participation rate that appears to have increased the percentage of weaker and unmotivated students, and may be the primary cause of the large increase in drop-out rate over the years.

5. These results raise the question of how much other interesting data can be mined from the double-cohort years. This will be more difficult now that these students have graduated and dispersed.

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